ASU Decision Theater® Network
Arizona State University

Voting Precinct Design Tool

Resource Optimization for Election Administrators

Q3 2017

Summary

For purposes of conducting elections, entities such as counties or townships are typically subdivided into precincts with residential addresses assigned to specific precincts. Each precinct has specific locations where residents go to vote. Sometimes several precincts use the same polling station. County Recorders and Election Administrators find voting precinct design techniques to be resource-intensive and sub-optimal. Geographic Information System (GIS) mapping software affords a partial solution, but heretofore GIS approaches have relied mainly on trial-and-error techniques to tackle challenges associated with cross-layer spatial reconciliation and optimization. Arizona State University's Decision Theater has developed a voting precinct design tool to automate the current error-prone process. A multi-objective optimization algorithm (1) minimizes the total number of precincts; (2) minimizes total weighted travel distance within precincts; and (3) minimizes number of splits in other spatial layers that can be divided if necessary. Additionally, the tool ensures that mandatory spatial districts (e.g., congressional and legislative) are not divided within any precinct, allows users to specify which additional layers cannot be split, and ensures that the maximum number of voters per precinct specified by the user is not exceeded. The tool is delivered through an online web interface with the algorithm operating in the background. The Voting Precinct Design Tool is easy to use, even by non-technical organizational leaders and staff members. Its inherently flexible design allows integration of new spatial layers for new geographic regions and applications/purposes.

Precinct Design Challenges

Precinct design and polling place siting is currently a resource-intensive process that plays a critical role in ensuring an efficient and well-executed election process. Failure to design optimal precincts can have an adverse effect on resource allocation, resulting in long lines and voter dissatisfaction. Existing challenges including staffing, polling location selection, ballot design and processing, and others could be mitigated if the process were better optimized. Additionally, County Recorders frequently come under scrutiny for precincts that violate policy, split individual parcels, or (dis)advantage particular communities. While there are no easy solutions for depoliticizing and streamlining this process, software tools are now available that can minimize these challenges while increasing efficiency and improving accuracy.

A partial solution: Geographic information system mapping tools

Commonly employed techniques for precinct design and polling place siting are considerably lacking in sophistication. In many smaller counties, precinct maps are created by hand, on paper, in a boardroom or central office. In larger, more populous counties, elected County Recorders typically employ professional staffs who design precincts using commercial, off-the-shelf Geographic Information System (GIS) software. Esri's ArcGIS tool is an example and a dominant player in this industry. There are a host of smaller firms producing similar software, some of which are open-source.

Even with GIS software, precinct design is a lengthy, resource-intensive, trial-and-error process that inherently results in efficiencies and a multitude of errors. The typical approach requires highly-skilled GIS technicians who possess both technical proficiency and understand nuances of local policies governing election administration, federal laws, and continually shifting socio-political landscapes. Even when employing GIS software, precincts are drawn and adjusted manually as there is no tool that is readily available in GIS for precinct design.

In order to create precincts, GIS technicians must overlay a variety of geographic layers (e.g., congressional districts, legislative boundaries, school districts, sanitary districts, etc.) while at the same time mentally balancing competing

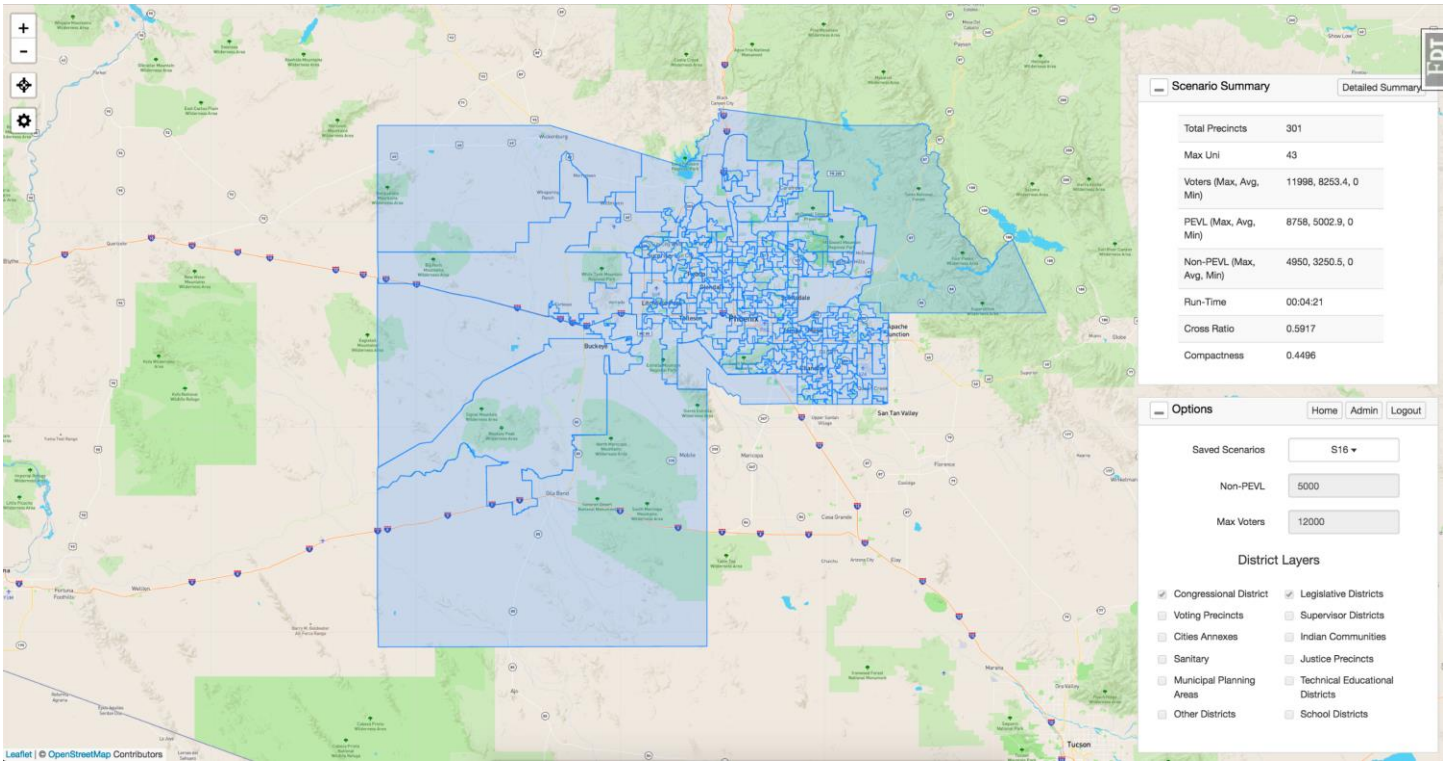

Fig. 1. Voter Precinct Design Tool. Optimal precinct boundaries for Maricopa County, Arizona are drawn in an automated fashion based on user input.

legal and political considerations. The trial-and-error process is challenging given the many dimensions that GIS technicians need to consider simultaneously. These "cross-layer" spatial optimization challenges are exacerbated when errors exist in the underlying spatial databases—a common challenge caused by manual digitization, outdated spatial information, and several other error-causing challenges.

At the end of the day, the advent of GIS software has not changed the precinct design process much—the boundaries are still drawn by hand—albeit on a computer screen—and subject to human bias and error. This results in flawed precincts and sub-optimal resource allocation. In addition, because this process is so time-consuming and labor-intensive, it is not done often enough to keep up with population shifts. Thus, between design events, precinct populations can grow or shrink, which affects the efficient use of resources on Election Day.

A complete solution: The Voter Precinct Design Tool

The Voter Precinct Design Tool is a decision-making and resource-management tool that automates the precinct design process through a web-based interface. Figure 1 depicts an instance of the tool tuned for Maricopa County, Arizona. Precincts are optimized based on user-selected input parameters, which a County Recorder's Office could base on factors such as local statutes and laws, ballot equipment limitations, no-split district lines, etc. The settings, which are adjusted using the "options" box in the lower right corner of the tool, include:

- Max # of Non-Permanent Early Voting List (PEVL) voters (default value: 1,500)
- Max # of voters in precinct (default value: 4,500)
- Split/no split categorization of district layers:
  - Always Mandatory No-split: Congressional and legislative districts. For legal reasons, these

districts cannot be split, i.e., only one such district can exist within each precinct.

- Optional No-split: The user can optionally designate a layer as no-splits allowed for a particular scenario. The algorithm will then enforce this rule for all such layers.
- Other: For all other layers, the algorithm will try to minimize the number of splits, but will allow splits if necessary.

The three different "no-split" categories classify layers based on whether multiple districts are permitted to exist in any single precinct. While congressional and legislative districts cannot be split for legal reasons, other layers (e.g., school and sanitary districts) can be divided within precincts at the discretion of the user. Figure 2 provides an illustration of a split precinct.

After the user authenticates into the web-based system, a new scenario can be generated by adjusting input parameters or selecting a pre-calculated scenario. Based on user-determined constraints and inputs, a multi-objective optimization algorithm generates precincts based on the following priorities:

1. Minimizing total number of precincts (reducing the number of different versions of ballots to be printed, and other associated costs).
2. Minimizing total voter-weighted travel distance within precincts (thereby creating smaller and more compact precincts).
3. Minimizing the number of splits in districts of other spatial layers that can be divided if necessary.

In summary, the Voter Precinct Design Tool leverages an optimization algorithm to minimize splits within districts while also ensuring that the maximum number of voters per precinct specified by the user is not exceeded and mandatory spatial districts (e.g., congressional and legislative) are not divided within any precinct. Since input parameters are always honored, human error is eliminated altogether. This provides election administrators with an unprecedented ability to run various scenarios and employ strategies aimed at optimizing available resources.

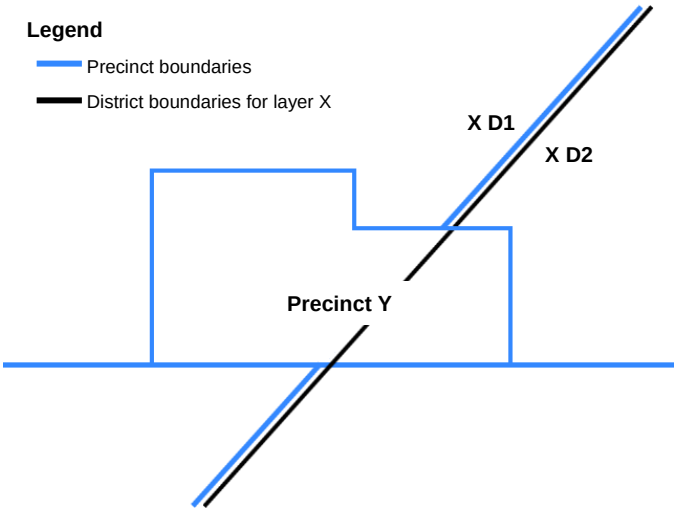

Fig. 2. Example of a split in a precinct. Precinct Y is split between Districts 1 and 2 of Layer X. Such splits are never allowed for districts classified as always mandatory no-split. For other layers, however, the user can choose whether splits are not allowed (optional no-split) or are discouraged (other).

Future Capabilities

Future iterations of the tool will focus on the following enhancements:

- **Decreasing computation time**. The tool currently requires 5-30 minutes to fully calculate a scenario on a conventional laptop computer. Future development phases will reduce this time, thereby enabling County Recorder staff to quickly and easily re-optimize precinct boundaries under many different specifications.
- **Increasing algorithmic sophistication**. The current version prioritizes minimizing the number of precincts created and then tries to balance maximizing compactness and minimizing the number of splits of non-mandatory layers. Future

iterations of the tool will allow the user to analyze the tradeoff between the number of precincts created, the number of splits introduced, and compactness. This extension would generate tradeoff curves to improve understanding of conflicting objectives and enhance ability to prioritize certain objectives and look for win-win solutions.

- **Optimizing polling station locations.** Given a set of potential, publicly available polling sites, this tool could optimally locate the user-specified number of polling stations and allocate precincts to their closest stations.
- **Automate pre-processing.** Even with the new tool, substantial effort is needed to prepare and clean the GIS data for input to the tool. A transparent process has been developed for doing this, but it remains time-consuming. This task would develop a toolkit for efficient, automated data pre-processing.

Conclusion

The Voter Precinct Design Tool is a web-based decision-making tool leveraging an optimization algorithm to automate the precinct design process. As a result, election administrators can simulate multiple polling scenarios and choose the optimal precinct design that best improves the allocation of resources. This process increases transparency, leading to buy-in from a wide variety of stakeholders. The inherent flexibility of the tool allows for adoption by any voting administration body as well as easy adaptation to new or evolving local, regional, or statewide districting considerations.